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A PEPPER FRUIT ROT NEW TO THE UNITED STATES

By B. B. Higgins

During the past two years a very destructive rot of pepper fruits (*Capsicum annuum* L.) has been found in limited areas in middle Georgia. It was first reported to the Experiment Station from Dyas, Monroe County, where the disease was very destructive on Pimiento during 1929. Inquiry at a cannery in Griffin developed information that Pimientos affected with this rot had been received from certain farms in Monroe and Lamar counties during 1928. Unverified reports indicate that it occurred in Bibb and Monroe counties in 1927. During 1929 canning season the disease was found on Pimientos in very destructive form on one farm in Henry County. Some growers of Pimientos in Lamar County estimated their loss at 50 per cent of the crop.

While many phases of this disease remain obscure, it appears advisable to issue this preliminary report to inform pepper growers and canners of the seriousness of the disease and warn them of the danger of introducing it into regions where it does not now occur.

Characteristics of the Rot

No noticeable symptoms of disease appear until the pods ripen. As they turn red, whitish or light pink spots, more or less circular in outline and 1/8 to ¼ inch in diameter (Pls. 2 and 3), appear over the surface. The spots may be slightly sunken and in some cases may bear acervulae and scattered clumps of black setae of the causal fungus.

Since these spots are not conspicuous they are usually overlooked by growers when grading pepper for the cannery. Often such diseased fruits are picked and bagged or piled in a truck for delivery at the cannery the following morning. During the night sufficient moisture accumulates to allow rapid growth of the fungus; and by the following morning most of the spots will have become water-soaked, softened, very much enlarged, ¼ to 1 inch in diameter, and dirty brown to nearly black toward the center with a reddish brown border. Frequently the centers of such spots are completely covered with a pink mass of spores. Such fruits are worthless for canning. At the canneries it is a common experience to find a load of pepper, from fields where the disease is present, graded sound the previous afternoon deteriorated during the night to such an extent that 50 to 75 per cent must be thrown out.

During damp, rainy weather the rot develops rapidly and the fruits are completely decayed in the field.

Microscopic examination of the diseased spots shows numerous acervuli, with stiff black setae scattered amongst short conidiophores (Pl. 1, figs. 2 and 3), seated in a more or less stromatic structure developed within the epidermal cells. The conidiophores are sparingly branched (Pl. 1, fig. 3). The setae are straight or curved, 48–96 by 3.5–6 μ, and tapering toward the distal end.

The conidia are curved, often falcate with rather abruptly pointed ends, 16.8–26.4 by 3–4.2 μ, colorless under the microscope, 1 or 2 guttulate.

Numerous black sclerotial bodies are found within the decaying tissues, especially toward the inner surface of the hull. They are usually globose in outline; but frequently two or more primordia fuse to form an irregularly flattened structure. They are pseudoparenchymatous, composed of irregular-shaped, thin-walled cells, colorless at the center. Toward the surface the cells become more filamentous in character with dark brown cell walls. The sclerotium is usually covered with the free ends of the filaments from which it has developed.

The fungus grows rapidly on all artificial media tried. On potato, lima bean, and beef-extract peptone agars aerial mycelium is rather scanty. After a few days acervuli form over the surface and pinkish masses of conidia may be seen. Often in the cultures the pink spore mass covers the entire surface of the medium.

IDENTITY OF THE FUNGUS

The causal fungus appears to be identical with *Vermicularia capsici* Syd., described by Sydow[8] as occurring on pepper fruits sent him from Madras Presidency, India. Since that time it has been reported by Dastur[1] and others as causing a serious fruit rot and a die-back of young growing branches during periods of high humidity. The latter type of injury has not been found in Georgia. The development of the fruit spots, as reported by Dastur, is slightly different from that noted here. He says (1 c. p. 130), "The first outward sign of infection is the appearance of a small black, circular speck, generally sharply defined but at times diffused." However, Sydow, in his original description, refers to the sporodochia as densely aggregated on white spots. Observations indicate that under our conditions the spots are at first white or yellowish to pink, and during periods of low atmospheric humidity they may remain in this condition for several days, while under very humid conditions they may develop more nearly according to the observations of Dastur.

The morphological characters of the Georgia fungus would seem to place it in the genus *Colletotrichum;* but they agree very closely with the description and illustrations of *V. capsici* Syd. It is, therefore, tentatively referred to this species until authentic specimens can be compared.

The recent appearance of the disease in this region cannot be explained satisfactorily at this time. The fungus may have been brought in on pepper seed imported from India. On the other hand, it may have been present for years on other host plants and only recently spread to pepper. Sundararaman[7] reports that *V. capsici* occurs on chillies, tumeric (*Curcuma longa*), cabbage, and other crucifers in Madras. He succeeded in inoculating several other species with the same fungus.

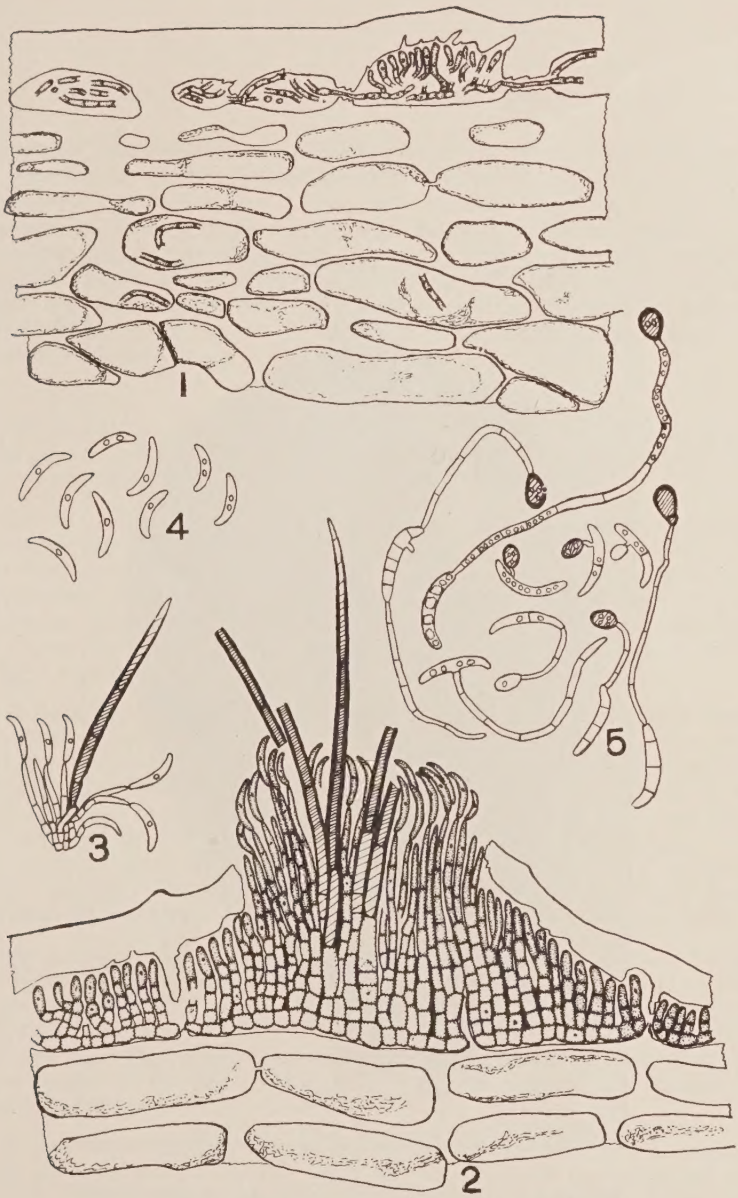

PLATE 1

Fig. 1. Section through a white spot on a Pimiento pepper fruit. The epidermal cells are packed with mycelium of the fungus, V. capsici, and the hyphae have penetrated to a few of the uncutinized parenchyma cells beneath. X about 400.

2. Section of an older decayed spot from same, with a mature apothecium.
3. Group of conidiophores with conidia and a single seta.
4. Free conidia.
5. Germinated conidia after 24 hours in a moist chamber. Most of them have formed black appresoria in contact with the glass.

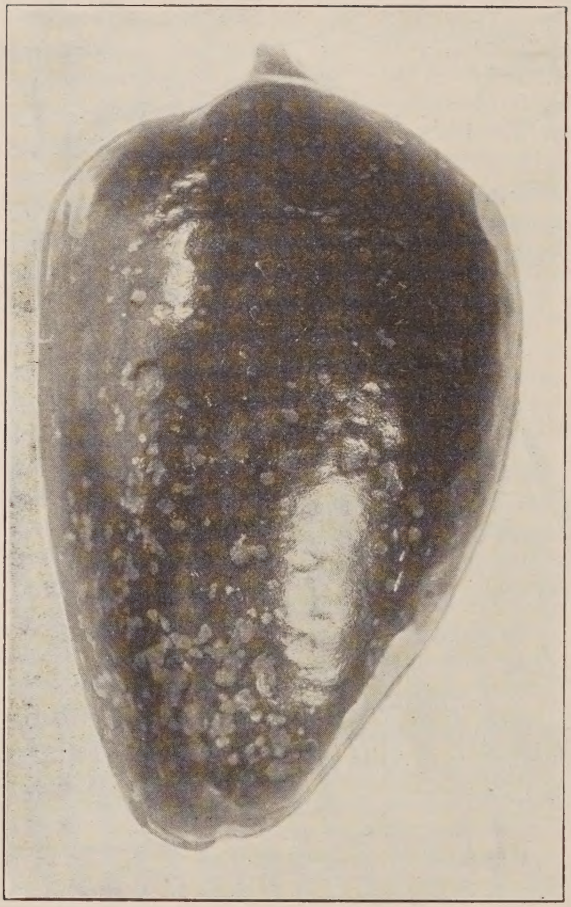

PLATE 2.
Ripe Pimiento pepper fruit showing light colored infected spots 6 days after inoculation with **V. capsici Syd.**

Thompson[9] has reported its occurrence on egg plant; and McDonald[5] has reported a similar disease on Madagascar butter beans, *Dolichos lupiniflorus*, and pigeon pea. It is also possible that the disease may have been present on pepper in America for years and its identity with the Indian fungus not recognized. There is still considerable confusion as to identifications in this group of fungi. Malabanan[4] described a pepper rot occurring in the Philippines as due to a fungus he believed to be *Colletotrichum nigrum*. His illustrations, however, show that it is probably *V. capsici*.

Inoculations

All inoculations were made on pot grown Pimiento pepper plants in the greenhouse. These plants were free from diseases of all kinds and no other pepper was growing near the greenhouse.

In the first series, conidia from a 14-day-old culture were suspended in a small amount of sterile water. With a camel's-hair brush this spore suspension was painted over the surface of five fruits varying in development from very young to mature. Each fruit was then wrapped with moist absorbent cotton which was kept moist through four days. As a check, four fruits on another plant were wrapped with moist cotton and kept moist over the same period.

No evidence of infection was noticed on the inoculated green fruits; but as they ripened spots began to appear on all of them. In some cases these spots were sunken and water-soaked from the first; but most of them first appeared as pale yellow areas. After a few days some of the latter appeared water-soaked and enlarged rapidly. Others remained dormant until the pod was placed in a moist chamber over night. The next morning most of these were water-soaked and decay extended entirely through the hull parenchyma. Each of the inoculated fruits developed 6 to 50 spots. All the checks matured and ripened normally.

On another plant with four fruits one inch long (about 7 days after blossoms shed), three fruits were inoculated by the above method and the fourth held as check. Again there was no evidence of infection until the fruits were ripe which was one month after inoculation. Then numerous spots developed on each inoculated fruit. Acervuli of the fungus appeared on one of the peduncles also. Again the check pod remained healthy.

In another series four mature fruits, one turning red, were inoculated by the same method. On the sixth day spots began to appear on the ripe pod. As the other three ripened the spots appeared on them also. Two weeks after inoculation numerous spots had developed on each inoculated fruit.

The results show that the Pimiento pepper fruit is susceptible to infection at all stages of development but no decay develops until the fruits are red ripe. Apparently the germ tubes from the fungus spores

penetrate the cuticle of green fruits and after growing for a time within the epidermal cells become somewhat dormant until the fruit is ripe. When ripe fruits become infected the mycelium quickly spreads through the soft fleshy parenchyma of the hull, producing a soft rot. Here the incubation period is six days, or perhaps less in fully ripe fruits. In green fruits, on the other hand, the fungus may remain dormant for a month or more without producing any symptoms evident on the surface.

The development of infection in green fruits has not been followed carefully through all stages, but stained sections of the small yellowish spots on ripe fruits show the fungus mycelium within the epidermal cells only, or with occasionally a few hyphae in dead cells immediately beneath the epidermal layer. In the epidermal cells the mycelium has formed compact mats rupturing the cells and lifting the cuticle and upper portion of the cell walls, thus forming an air pocket. This air pocket and the mycelial mat give the pale yellowish to white color to the spot at this stage.

Under moist conditions this dormant mycelium starts growth again; quickly penetrates the underlying cells—which in ripe fruits are rich in sugar—and causes their rapid break-down. The liquid from these collapsed cells causes the water-soaked appearance of the spot.

Gloeosporium piperatum E. & E. is capable[2] of infecting ripe Pimiento fruits and also the green fruits at certain stages before the cuticle is well developed; but produces decay at once in both green and ripe fruits, while the *Vermicularia* produces decay in ripe fruits only. The disease produced may, therefore, be properly designated "ripe rot."

SEED INFECTION

As the spots develop fungus mycelium passes through tissues of the hull and into the central cavity where it comes in contact with the seed. The mycelial growth in the cavity is not very conspicuous; but black sclerotia are produced in profusion on the inner surface of the hull, sometimes in contact with the seed. Many of the seeds become dark colored, indicating that mycelium has entered the seed coat. Some of our results indicate that mycelium often enters the hilum, or point of attachment, of the seed without producing any surface discoloration. Furthermore, in the process of coring and taking seed from infected fruits the seed become smeared with spores which cling tenaciously to the seed coat.

When such infected and contaminated seed are planted the cotyledons (seed leaves) of the young seedlings become infected and the fungus is thus carried to the fields again. This is shown conclusively in results obtained with three lots of seed from infected pods from different fields. Each lot was divided into several portions, some of which were surface disinfected before drying. Others were treated after drying, and checks were held without treatment. Among the treatments used on fresh seed were hot water 50° C. (120° F.) for 15, 20, 25, 30,

PLATE 3.
Pimiento pepper fruit showing diseased spots in various stages of development.

40, 50 and 60 minutes, mercuric chloride solutions, Uspsulun solution, and Semesan solution. The same treatments and also a number of organic mercury dusts were used on dry seed. The effects of the treatments on seed germination and on the seed-borne fungus were ascertained on agar plates, in the seed germinator, and in pots of sterilized soil.

The results indicate that no surface disinfectant treatment can be relied upon to make infected seed safe for planting, since some seedlings showed infection after each treatment. Apparently the surface-borne spores were killed by most of the disinfectants tested but the fungus inside the seed coat was not destroyed. When surface disinfected seed were plated on sterile agar the fungus was seen to appear about the hilum of a few seed. In soil the untreated seed produced 1 to 16 per cent of infected seedlings. An occasional infected seedling was found in lots given even the most severe disinfectant treatment, e. g., mercuric chloride solution or hot water 50° C. for one hour. Similar results have been reported[2] with seed from anthracnose (*Gloeosporium piperatum* E. & E.) infected fruits.

It seems impossible to free seed of all forms of infection without severe injury to germination. It would appear, therefore, imperative that growers and canners should learn to recognize anthracnose and ripe rot and avoid saving seed for planting from fields where either of these diseases occurs.

Tests over a period of ten years have shown that seed treatment is quite effective in destroying seed borne spores of other noxious fungi and bacteria. For this purpose soaking the fresh seed 30 to 60 minutes in a solution of Semesan, 1 part by weight of Semesan to 400 parts of water, and then drying is quite effective, and is easily and cheaply done. Some canneries of Georgia are now treating, by this method, all seed furnished their growers; but, since this treatment cannot be relied upon to rid seed of anthracnose and ripe rot fungi, growers must take the additional precaution of selecting planting seed from fields free of these two diseases.

Reports [1] & [6] on spraying tests in India indicate that the disease may be effectively controlled by spraying with Bordeaux or with Burgundy mixture; but we cannot, as yet, be certain that similar results may be expected under our conditions.

Summary and Conclusions

1. A ripe rot of pepper fruits, not previously reported, has been very destructive in limited areas in Georgia during the past two seasons. Observations during this period indicate that it may become one of the most serious diseases of this crop.

2. The disease is due to a fungus, apparently identical with *Vermicularia capsici* Syd. which causes a die-back and fruit rot of Chili pepper in India.

3. The fungus is seed-borne, occurring both internally and on the surface of the seed.

4. It is possible to destroy the surface-borne fungus spores with liquid and dust disinfectants; but, apparently, sub-surface infection is not destroyed; therefore disinfectants are not dependable for making seed from diseased fruits safe for planting. Consequently, seed from diseased fruits should not be used for planting.

5. Whether the fungus lives over winter in soil or on the diseased plant has not yet been determined.

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